TITLE OF INVENTION

Applicant

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Title

Arrangement for using induction motor as a sensor to sense its own rotation when electrical power is not being supplied to it

CROSS-REFERENCE TO RELATED APPLICATIONS

Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERENCE TO A MICROFICHE APPENDIX

Not Applicable

BACKGROUND OF THE INVENTION

There are various ways of sensing the rotation of an induction motor. Tachogenerators, resolvers and Hall-effect sensors are some of the conventional sensing devices. But all such sensing methods entail the use of additional hardware on the induction-motor frame itself. In many applications, where there are cost constraints, it may not be possible to use additional sensing devices on the motor frame. In existing machines, due to physical constraints, it is, many a time, not possible to do hardware modifications on the

mechanical design. When an induction motor is being driven by using a variable-speed AC drive, it is possible to estimate, define or know the angular movement of the rotor. But when the power to the drive is turned off, and the induction motor keeps rotating either due to its rotor's moment of inertia or due to some external mechanical force, it is not possible to sense the angular movement of the rotor of the induction motor without the use of an extra device coupled with the frame of the induction motor.

In many applications, it becomes essential to be able to sense the angular movement of the rotor of the induction motor after electrical power driving the motor has been switched off: Like in the case of the high-rpm induction motor driving high-speed grinding wheels resting on oil-fed hydrostatic bearings. At the times of sudden power failure, if the grinding wheels are in rotation, it is essential to continue oil supply to the hydrostatic bearing. As there are physical constraints in introducing an additional conventional sensor in the above-mentioned example, the present invention was successfully introduced, which utilized the driving induction motor itself as a sensor for the rotor's angular movement. There are low-cost areas of application, like electrical saws and industrial blowers; where the sensing of rotation of the driving induction motor can provide a safety interlock -- the advantage would be that no alteration has to be done in the electro-mechanical construction of such equipment.

BRIEF SUMMARY OF THE INVENTION

The rotor of any induction motor is in the form of multiple shorted secondary windings of a transformer. The electrical conductor is made either of Aluminium or Copper; the magnetic circuit comprises of Silicon-Steel stampings stacked together. When power is switched off to an induction motor, the residual magnetism of the Silicon-Steel stampings form multiple

poles on the angular face of the rotor. These multiple magnetic poles induce minute electrical current in the stator windings just like in a small alternator. The frequency of the output voltage generated in this manner is directly proportional to the angular movement of the rotor of the induction motor. Contactors and relays are arranged in a manner so that this sensor voltage could be directed to an amplifier and/or counter to be able to draw inference from the sensor signal.

Nearly four years back the object of the invention was to give a starting command to a three-phase battery-driven inverter to keep running the oil-pump motor till the time the grinding wheels of a Toyoda* Cam Grinding Machine came to a stop. These grinding wheels rested on a precision hydrostatic bearing to which the oil pump constantly keeps pumping oil. In a hydrostatic bearing, maintaining a required oil pressure in the bearing is a must; and the absence of which even for a brief while damages the expensive bearing, making it unserviceable.

During the last four years the invention has been implemented on several similar machines to obtain the same objectives as described above. The absence of any external device on the induction motor makes this invention particularly easy to implement. Many a time it is physically impossible to accomodate any piece of hardware in and around an induction motor; in these circumstances the present invention could be of particular use. In addition, in applications where even when the motor is not powered, but is rotating due to some other mechanical linkages, this invention could be used to quantify that movement without using any conventional additional device like tachogenerator, resolver or encoder -- thus saving both cost and space.

*Toyoda Machine Works Ltd, Kariya, Aichi, Japan

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG.1 is an electrical circuit diagram showing the arrangement described in the description of the invention.

DETAILED DESCRIPTION OF THE INVENTION

In most of the general-purpose induction motors, the rotor is of squirrel-cage arrangement, where the shorted secondary windings of the induction motor are placed. The primary winding generally is on the stator. The magnetic circuit of the induction motor consists of Silicon-Steel stampings stacked together to reduce eddy-current losses in the magnetic circuit. After an induction motor is switched off from the mains supply, theoretically, the residual magnetism of the ferro-magnetic magnetic circuit tends to be zero. Still, little bit of residual magnetism remains in the rotor as well as the stator. Weak but distinct permanent magnets formed on the rotor, make the induction motor rotating without electrical driving power, function as an alternator producing weak but distinct electrical waves. Till now, this miniscule signal used to get sunk in the mains power lines, and went unobserved. The Voltage and the frequency of this tacho signal is proportional to the rpm of the induction motor running due to its moment of inèrtia in the absence of electrical motive force. Gradually the rotor of the induction motor comes to a halt. This is when the signal coming out of the stator winding stops. Generally, the rms value of this signal voltage is between 30 and 0.1 Volts for practical sensing applications to be successfully implemented. At Voltage levels below 0.1 Volt, the noise Voltages interfere, and discrimination of the signal deteriorates. Most of the three-phase induction motor supply lines have a contactor in series with the mains supply to turn the induction motor on and off. Even when the induction motor is being driven by a variable-speed drive, usually there is a three pole contactor in conjunction with an Over-Current Relay to turn off the induction motor in case of emergencies. This contactor (CN 1 in FIG.1) in series with the mains supply to the three inputs (U,V,W in FIG.1) disconnects

the motor from the mains supply as soon as the mains power is disconnected or is turned off. At this instance, two connexions to any two of the three inputs U, V and W (FIG.1) going through two independent normally-closed contacts of a relay or a contactor reach the tacho signal from the induction motor acting as a residual-magnet alternator to an amplifier and/or counter. This two-pole double-throw contactor or relay (CN 2) is of much lower rating than the main motor-control contactor CN 1 in FIG.1. CN 2 and CN 1 could be driven by any logical signal or directly by the mains supply.

Due to high moment of inertia, in many cases, induction motors connected to freewheeling loads like high-speed grinding-wheel assemblies keep revolving for nearly 10 minutes before stopping. In the case of this self-generated tacho signal being amplified after a mains-power failure, the amplifier and/or counter needs to have a power source. this could be incorporated in the amplifier section in the form of appropriate rechargeable battery or a high-value super capacitor.

In some applications -- as was the case of providing starting trigger Voltage to a three-phase UPS -- the self-generated tacho signal can be directly applied after simple full-wave rectification utilizing a bridge rectifier. In such applications, the UPS or the battery-driven inverter runs for a preset time after receiving a start signal from the self-generated tacho output of the induction motor whose angular movement was to be known.

In the application of this invention it is important that three-core or twin core **shielded** cables are used to wire CN 1 and the motor M (in Fig. 1). Number of cores in the shielded cable depend upon whether the motor in question is single phase or three phase. The external shield of the cable has to be grounded, preferably, on both the ends.

When an amplifier and/or counter is used to process the self-generated tacho signal from the application motor,

it is important to have an overvoltage protection circuit at the front end of the amplifier and/or counter module. this would prevent the amplifier from getting damaged if the relay contacts of CN 2 (FIG.1) get stuck; in that case full motor supply Voltage will appear at the input of the Amplifier and/or counter.

Most of the windings of induction motors are of fairly low impedence. This improves the signal to noise ratio of the self-generated tacho signal coming out of the motor stator windings. Furthermore, induction motor housings are electrically and magnetically fully shielded; which prevents external sources of noise from breaking in. The robustness of construction, low source impedence and ease of use make this self-generated tacho output from any induction motor a more suitable solution in some mains hold-up or power-off applications compared to the use of an additional sensor with the induction motor to know the angular movement of the rotor of the motor.

In another addition to the application, CN 2 in FIG.1 could be of 3-pole type. The three-phase selfgenerated tacho output is sent to an amplifier discriminator to detect the phase relationship between the three signal phases. This will logically indicate the direction of rotation of the rotor of the induction motor.

In comparatively smaller-capacity induction motors, the use of CN2 could be avoided by using CN 1 contactor with auxilliary normally-closed contacts. In large contactors, auxilliary contacts would tend to catch the deposits emanated out of the main motor contacts' make and break.